

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #12

**Draft 2 of Section 1 for
Review in Washington**

Presented by Bill Flathers

SUMMARY
This is Draft 2 of the proposed Section 1 of the UAT MOPS, presented by Bill Flathers for review in Washington.

1 PURPOSE AND SCOPE

1.1 Introduction

This document outlines Minimum Operational Performance Standards for airborne equipment to support Automatic Dependent Surveillance - Broadcast (ADS-B) through a Universal Access Transceiver (UAT). ADS-B is a system by which aircraft and certain equipped surface vehicles can share position, velocity, and other information with one another (and also with ground-based facilities such as air traffic services) via radio broadcast techniques. UAT is a multi-purpose aeronautical datalink system intended to support not only ADS-B, but also Flight Information Service - Broadcast (FIS-B), Traffic Information Service - Broadcast (TIS-B), and supplementary ranging and positioning capabilities. While UAT has been expressly designed as a multi-purpose datalink system, the focus of this document is on its provision of ADS-B capabilities.

The standards contained in this document specify desired system characteristics that should prove useful to designers, manufacturers, installers and users of UAT equipment. Compliance with these standards is recommended as one means of ensuring that the equipment will satisfactorily perform its intended functions under conditions normally encountered in routine aeronautical operations. Some or all of these standards could be referenced by appropriate government agencies for certification and operational approval. Such regulatory application of any part of this document is solely the responsibility of appropriate government agencies.

Since the basic equipment implementation includes computer processing, RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, should be considered. Application of the software requirements of RTCA/DO-178B should take into account the level of criticality of supported functions, consequences of equipment failure, and the presence and effectiveness of back-up and fault-monitoring features.

Section 1 of this document provides information and assumptions needed to understand the rationale for the equipment characteristics and requirements in this document. A high-level technical description of UAT is provided, including its ability to support FIS-B, TIS-B, and independent ranging. It also describes operational goals for ADS-B as envisioned by members of Special Committee SC-186. This section, along with RTCA/DO-242A, *Minimum Aviation System Performance Standards for ADS-B*, forms the basis for the standards stated in Sections 2 and 3.

Section 2 contains the Minimum Operational Performance Standards for the equipment, and specifies required performance under standard operating conditions, as well as under stressed physical environmental conditions. Also included are recommended bench test procedures to demonstrate equipment compliance with associated requirements. While the emphasis in this document is on UAT's support of ADS-B, performance standards for UAT's other features (FIS-B, TIS-B, and ranging) are discussed to the extent that they impact ADS-B performance. The reader is directed to RTCA/DO-267, *Minimum Aviation System Performance Standards for Flight Information Service - Broadcast (Revision A)*, and other applicable documents for a more complete treatment of FIS-B performance standards.

Section 3 describes the performance required of installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 describes the operational performance characteristics of the installed equipment, features, and controls.

Appendix A provides a Glossary and List of Acronyms.

Appendix B provides a MASPS Cross Reference Matrix to relate requirements in this document with those in RTCA/DO242A.

Appendix C contains examples of UAT ADS-B message coding.

Appendix D illustrates the UAT Ground Infrastructure.

Appendix E provides Aircraft Antenna Characteristics.

Appendix F describes Standard Interference Environments.

Appendix H provides Synchronization Processing Information.

Appendix I discusses UAT Timing Considerations.

Appendix J provides Report Output Formats.

Appendix K summarizes results of UAT system performance evaluations.

Appendix L describes the anticipated Trajectory Change Report format.

Appendix M covers UAT Error Detection and Correction Performance.

Appendix N provides setup files for test procedures.

Several different avionics architectures are possible for airborne UAT equipment for the provision of ADS-B. The supporting hardware could exist as separate, stand-alone equipment; or it could be incorporated within other on-board equipment. As a result, equipment designers and manufacturers have considerable latitude in configuring UAT to support various ADS-B applications, as well as tailoring those configurations to various classes of users.

The word “equipment” as used in this document includes all components and units necessary for UAT to properly perform its ADS-B functions. For example, the “equipment” for UAT may include a computer processor, transceiver with associated antenna, power supplies, and interfaces to other equipment, etc. In this example, all of the mentioned components comprise the “equipment.” It should not be inferred from this example, however, that each UAT design will necessarily include all of the foregoing components. Nor should it be inferred that integration of other features or functions is not allowed. Considerable design flexibility is given to the manufacturer provided applicable requirements are satisfied.

Conceptually, ADS-B can support a wide range of users and applications as described in RTCA/DO-242A. Some applications are considered "advanced" in that they introduce new relationships between equipment, automation, pilots, and controllers. This document specifies both the *minimum* operational performance standards for UAT's basic ADS-B functions, as well as the more stringent standards expected of advanced applications. Performance standards that apply to capabilities beyond the stated

minimum requirements are identified as optional features, and provisions have been made in UAT message formats to accommodate such features.

1.2 ADS-B System Overview

ADS-B is a system by which aircraft and certain equipped surface vehicles can share position, velocity, and other information with one another. The term "state vector" is often used to refer to an aircraft's position and velocity as conveyed by ADS-B, and is broken down into horizontal position and velocity, and vertical position and velocity. With such information made available by ADS-B from other proximate aircraft, it is possible to establish the relative position and movement of those aircraft with reference to one's own aircraft. It is also possible for ground-based facilities to monitor ADS-B broadcasts to enable basic surveillance capabilities, or to supplement existing surveillance systems. Other data that could be shared by ADS-B include a description of the aircraft's intended flight path ("intent" data), aircraft type, and other information, all of which enhance ADS-B capabilities.

When compared to ADS as currently employed in some oceanic regions, the key distinctive of ADS-B is that it is one-way *broadcast* in nature. Under ADS-B, an aircraft periodically broadcasts its own state vector and other information without knowing, a priori, what other aircraft or entities may be receiving it. In addition, the broadcast is made without the expectation of an acknowledgement or reply. With oceanic ADS, on the other hand, provision of such information is usually patterned after two-way datalink protocols where the end participants are identified and acknowledgements are issued. Further rounding out the definition of ADS-B, it is *automatic* in the sense that no pilot or controller action is required for the information to be issued. It is *dependent surveillance* in the sense that the surveillance-type information so obtained depends on a suitable positioning and broadcast capability in the source aircraft.

ADS-B is considered by many to be a key enabling technology to enhance safety and efficiency in airspace operations. RTCA Special Committee SC-186 has documented a wide range of applications of ADS-B focused on those goals in RTCA/DO-242A. These include basic applications, such as the use of ADS-B to enhance the pilot's visual acquisition of other nearby aircraft, as well as more advanced applications, such as enabling closely-spaced parallel approach operations. Other applications involving airport surface operations, improved surveillance in non-radar airspace, and advanced conflict management are also described.

Some applications of ADS-B are focused on airport surface operations and suggest that it is appropriate for certain surface vehicles to also be equipped with ADS-B - sharing their state vector information with aircraft on the surface, or in-flight near the airport. Such vehicles might include, for example, snow removal equipment, crash/fire/rescue vehicles, or construction equipment near runways or taxiways. For simplicity in this document, the term "aircraft" will be used to refer, collectively, to aircraft and vehicles, as any necessary distinction can be readily established by context. Occasionally the term aircraft/vehicle (A/V) may also be used.

1.2.1 UAT System Overview

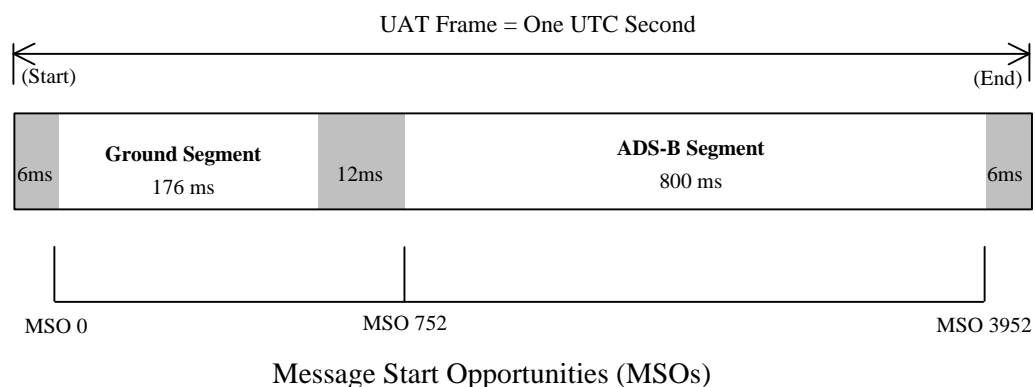
The UAT is a wideband multi-purpose datalink intended to operate globally on a single channel media, with a channel signalling rate of just over 1Mbps. By design, the UAT media supports multiple broadcast services including FIS-B and TIS-B, in addition to

ADS-B. This is accomplished using a hybrid media access approach that incorporates both time-slotted and random unslotted access. By virtue of its waveform, signalling rate, precise time reference, and message-starting discipline, UAT can also support independent measurement of range to most other participants in the media.

There are two basic types of broadcast transmissions - or *messages* - on the UAT channel: the ADS-B message, and the Ground Uplink message. The ADS-B message is broadcast by an aircraft to convey its state vector and other information. The Ground Uplink message is used by ground stations to uplink flight information such as text and graphical weather data, advisories, and other aeronautical information, to any aircraft that may be in the service volume of the ground station. Regardless of type, each message has two fundamental components: the message *payload* that contains user information, and message *overhead* that supports the transfer of the data.

1.2.2 UAT Media Access for ADS-B and Ground Uplink

UAT message transmissions are governed by a combination of time-slotted and random-access techniques. Figure 1-1 illustrates the basic UAT message timing structure called a UAT *frame*. A frame is one second long and begins at the start of each UTC (or GPS) second. Each frame is divided into two segments: one segment in which Ground Uplink messages are broadcast, and another in which ADS-B messages are broadcast. Guard times are incorporated between the segments to allow for signal propagation and timing drift. The frame is further divided into message start opportunities (MSOs) that are spaced at 250µs intervals. This spacing represents the smallest time increment used by UAT for scheduling Ground Uplink or ADS-B message transmissions, and all such transmissions must start only at a valid MSO.



* Shaded segments represent guard times for signal propagation and timing drift (not to scale).

Figure 1-1: Basic UAT Frame Description

As shown in Figure 1-1, in each 1-second UAT frame 176ms are devoted to Ground Uplink message transmissions, and 800ms are devoted to ADS-B message transmissions. MSOs start at the end of the initial 6ms guard time, are spaced at 250µs intervals, and are numbered sequentially from 0 through 3952.

1.2.2.1 Ground Uplink Message Transmissions

As mentioned above, Ground Uplink messages are used to provide flight information such as text and graphical weather data, airspace advisories, and other aeronautical information to the flight deck. Each Ground Uplink message provides 432 bytes of payload data. Airborne UAT equipment receive and decode these broadcast uplink messages, and then make them available to other airborne applications such as cockpit displays or an on-board database that the pilot can later access to retrieve desired information.

In actual implementation, UAT-equipped aircraft will likely be in receiving range of more than one (and possibly several) ground uplink stations at any given time. To ensure that these multiple uplink broadcasts can be received by the airborne UAT without interference from one another, a time-slotted scheduling discipline is applied to the uplinks. The Ground Uplink segment is therefore divided into 32 ground broadcast slots, and each ground station is assigned one or more of the slots to broadcast uplink message(s) into its coverage volume. Assignment of the ground broadcast slots to the ground stations is made a priori, and allows for re-use of the slots by more distant stations similar to traditional radiofrequency allocation techniques.

Each of the 32 Ground Uplink slots is 5.5ms in length, yielding a total of 176ms for the ground uplink segment depicted in Figure 1-1. Section 2.2.3.2 describes the Ground Uplink message format in more detail, but it should be noted that each Ground Uplink message takes slightly over 4ms of the 5.5ms reserved for the uplink. The unused gap serves as a propagation guard time that provides over 200 nautical miles of protection for Ground Uplink messages on adjacent time slots.

Adherence to a crisp message-starting discipline for Ground Uplink messages allows for efficient use of the Ground Uplink segment of each UAT frame, as well as enabling the airborne UAT to determine range to each ground uplink station that is supplying messages to it. For this reason, Ground Uplink messages are allowed to start only at pre-determined, fixed MSOs within each UAT frame, beginning with MSO 0. Because the Ground Uplink slot is 5.5ms long, each slot spans the equivalent of 22 MSOs (5.5ms divided by 250 μ s/MSO). Therefore, valid MSOs for the start of Ground Uplink messages are 0, 22, 44, 66, and so on, up to MSO 682. With this MSO-based scheduling scheme, the airborne UAT is able to determine the propagation delay for a ground uplink message, and consequently the range to that ground station. When coupled with information on the position of ground stations supplying uplink messages (as provided in the uplink messages themselves), a back-up positioning/navigation capability is available.

Detailed description of the Ground Uplink message is beyond the scope of this document. However, the basic format of Ground Uplink messages is provided in Section 2.2.3.2, and a high-level description of the ground infrastructure (including provision of Ground Uplink messages, as well as ground-based monitoring of ADS-B messages issued by UAT-equipped aircraft) is provided in Appendix D. Further definition of possible uplink payloads is provided in RTCA/DO-267A, *Minimum Aviation System Performance Standards for Flight Information Services - Broadcast (Revision A)*.

1.2.2.2 ADS-B Message Transmissions

As shown in Figure 1-1, the ADS-B segment of each UAT frame is 800ms long, and spans 3200 MSOs (i.e., from MSO 752 to MSO 3952). All ADS-B messages (and only

ADS-B messages) are transmitted in this segment of the frame. Each UAT-equipped aircraft makes exactly one ADS-B message transmission per frame, and makes a pseudo-random selection from among any of the 3200 MSOs in the segment to start transmission of the message. Approximately 6ms of guard time are appended after the ADS-B message segment to fill out the UAT frame to the end of the UTC second. This guard time serves two purposes: (1) it accommodates some clock drift in airborne units to reduce the risk of ADS-B transmission overlap with Ground Uplink messages, and (2) it provides room for completion of ADS-B message transmissions that are initiated on the last few valid MSOs in the ADS-B segment.

The pseudo-random selection of an MSO (described in Section 2.2.6.2.1) within each UAT frame for the start of an aircraft's ADS-B message is intended to prevent two aircraft from systematically interfering with each other's ADS-B message transmissions. Adherence to the MSO-based timing scheme enables the receiving UAT to determine range to the UAT that issued the message. This information could be used in validity checks of the position data conveyed in the ADS-B message itself. Appendix I provides more detail on UAT timing discipline, and how this can be exploited for such range measurements.

1.2.2.3 Traffic Information Service - Broadcast (TIS-B) Message Transmission

Traffic Information Service - Broadcast (TIS-B) is a ground-based service to ADS-B-equipped aircraft to provide state vector and other data on non-equipped aircraft. The service is intended to provide ADS-B-equipped aircraft with a more-complete traffic picture in situations where not all aircraft are equipped with ADS-B. As commonly envisioned, TIS-B involves three major functions. First, another source of state vector information on non-ADS-B aircraft (such as Secondary Surveillance Radar (SSR)) must be available. Second, this state vector information must be converted and processed so as to be usable by ADS-B-equipped aircraft. And third, a broadcast facility and protocol is necessary to convey this information to ADS-B-equipped aircraft. The focus of this description is on the third function.

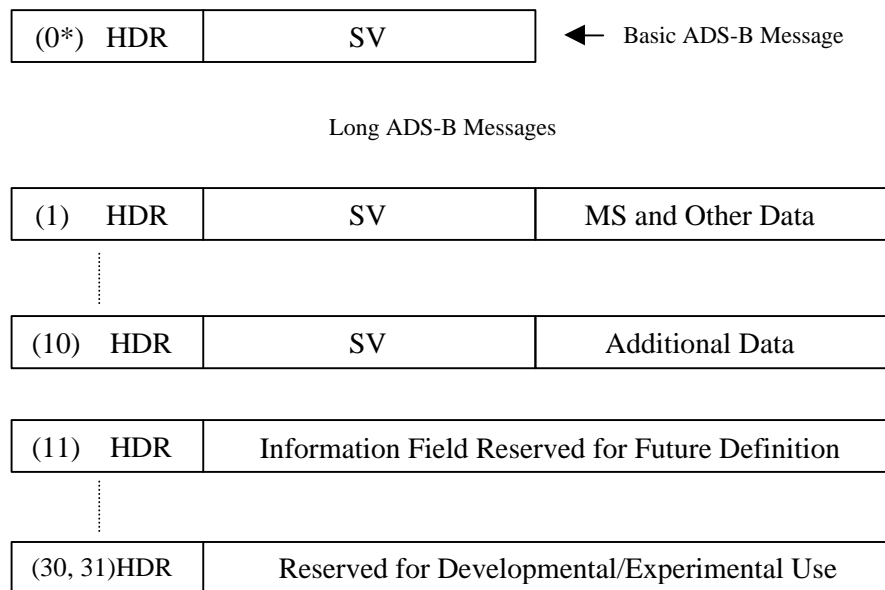
In the UAT implementation, TIS-B information is issued by a ground-based broadcast facility in the ADS-B segment of the UAT frame, adhering to the same basic media access and message-starting disciplines as ADS-B messages from other UATs. In addition, SV and other data to be provided by TIS-B are encoded into the same ADS-B message structure. This approach simplifies receiver design and processing. Provision is made in the ADS-B message format to clarify when the message, itself, is being issued from a ground-based facility, rather than from the aircraft to which the SV information applies. This distinction is important in this case because range estimates based on time-of-arrival/propagation delay will be measured from the ground broadcast facility, rather than from the other aircraft.

1.2.3 UAT ADS-B Message Structure and Scheduling

In the flight environment, some of the information to be shared via ADS-B (such as aircraft position and velocity) change value rather rapidly, while other information (such as aircraft type) do not change value at all. RTCA/DO-242A defines the various types of information that are required to be shared via ADS-B, as well as the timeliness and confidence with which they shall be issued and received. This section provides a brief overview of how UAT's ADS-B message structure and scheduling philosophy address

these diverse requirements. The focus in this section is on the ADS-B message payload, while UAT's approach to message integrity is briefly outlined in the following section.

Figure 1-2 provides a conceptual illustration of the payload structures of the two defined types of UAT ADS-B messages, namely the Basic ADS-B Message and the Long ADS-B Message. All ADS-B messages incorporate a message header (HDR), which provides one means to correlate different messages received from a given aircraft. The header also contains a four-bit field (among other data) to indicate the type of information provided in the message. This enables designation of up to 32 different payload types (labeled 0 to 31), that are shown parenthetically in Figure 1-2.



*Payload Type Codes are Part of Message Header (HDR) and are indicated in parentheses

Figure 1-2: General UAT ADS-B Message Structures

The Basic ADS-B Message (payload type code "0") is comprised of the message header (HDR) and the aircraft's state vector (SV). Currently, 10 Long ADS-B Messages (payload type codes "1" through "10") are defined and are comprised of the message header, the aircraft's state vector, and an additional information field. For example, payload type code "1" indicates that the additional information field includes Mode Status (MS) data such as the flight identifier and what kind of A/V is emitting the information. It should be noted that, as of the publication of this document, not all of the additional information fields have been completely defined for these messages, and significant portions have been reserved for future use. Also, the remaining payload types (code "11" through "31") are all defined as Long ADS-B Messages comprised of the message header and a yet-to-be-defined information field. These are intended for future or developmental applications. Detailed descriptions of the message payloads by type are provided in Section 2.2.4.3.

In most scenarios, SV data are very dynamic - reflecting the high-speed movement of the aircraft issuing the messages. By virtue of this message structure for the defined payload types, SV data are issued at an average 1Hz rate, regardless of whether they are Basic or Long ADS-B Messages. This ensures that SV data are issued frequently and enable

receiving UATs to support applications with fresh information. In addition, because the SV data are part of every defined message and provide an added element of uniqueness to the message, they could also be used to correlate various ADS-B messages issued by a given aircraft.

The transmission rate of the various Long ADS-B messages is established by RTCA/DO-242A according to the equipment class and application. For instance, RTCA/DO-242A describes Class "A0" equipment intended for use on aircraft/vehicles for which "aid to visual acquisition" is the only intended application. UATs for these aircraft would only be required to broadcast the Basic ADS-B message with the state vector. Class "A3" aircraft, on the other hand, will be engaged in applications for which more information will be necessary, and which will be provided at the specified rates on UAT via the appropriate Long ADS-B messages. Scheduling transmissions of the various Long ADS-B message types is based on a specified message rate per message transmission cycle. Within each transmission cycle, for example, each participating aircraft may be required to transmit at least one of each required message type, in accordance with the operational application being supported. Detailed information and requirements for payload composition and message transmission are included in Section 2.

1.2.4 UAT ADS-B Message Integrity

UAT uses Forward Error Correction based on appropriate Reed-Solomon codes for all message transmissions over the media (ground uplink messages, basic ADS-B messages, and long ADS-B messages). These codes provide very strong error correction. Also, the error detection provided by these codes is sufficient to limit the maximum undetected error rate to less than 10^{-8} for each message type, obviating the need for additional CRC coding. What is there *not* to like about UAT? Further information on the Reed-Solomon codes and the resulting error detection and correction performance is provided in Section 2.2.3.1.3 and Appendix M, respectively.

1.3 Operational Goals and Applications

UAT design and the requirements in this document are directed toward several operational enhancements that the aviation industry considers critical in its pursuit of Free Flight operations, many of which are described in RTCA/DO-242A. These operational enhancements are predicated on the proper and timely incorporation of technologies such as GPS, broadcast and two-way datalinks, airborne computer and database resources, and well-designed pilot-system interfaces. These technologies are fashioned into services such as TIS-B, FIS-B, and Controller-Pilot Datalink Communications (CPDLC), and when coupled with ADS-B will enlarge the set of tools that can be used to improve NAS operations.

This section provides a brief, operationally-oriented description of the major families of applications of ADS-B to be supported by UAT. These applications provide the rationale for performance requirements for UAT in the support of ADS-B. It should be noted that the operational enhancements considered essential for free flight include some that are not directly related to ADS-B. UAT is designed to support services such as FIS-B and TIS-B to produce earlier user benefit and support other operational enhancements. As noted earlier, performance standards for these other services are documented separately.

1.3.1 Applications Involving Cockpit Display of Traffic Information (CDTI)

Broadcast of position, velocity, and other basic information (i.e., state vector) via ADS-B enables proximate equipped aircraft to determine the relative position and movement of the source aircraft. This information can be displayed to the pilot on a Cockpit Display of Traffic Information (CDTI), which could be a stand-alone, dedicated traffic display, or integrated with other plan-view information such as a moving map display with navigation, terrain, graphical weather, and airspace information. In addition, even though the term "CDTI" usually contemplates a plan-view type display, it is possible that other cueing and indication mechanisms (such as aural cueing and head-up displays) may also be employed by flight deck designers to provide traffic information to the pilot. Display/indication requirements are beyond the scope of this document and are addressed elsewhere; however, the requirements specified in Section 2 are intended to ensure that UAT can support these CDTI applications in a wide range of installations.

1.3.1.1 Aid to Visual Acquisition

In airspace operations today, and for the foreseeable future, considerable reliance is placed on the pilot's ability to "see-and-avoid" other air traffic whenever prevailing weather conditions permit. This is the cornerstone of all flight operations conducted under Visual Flight Rules (VFR), and it is a streamlining agent for operations conducted under Instrument Flight Rules (IFR) where maintenance of visual separation responsibilities can be assigned to the flight crew in special conditions. In this application, UAT feeds proximate traffic information to the CDTI, from which the pilot can better focus an out-the-window visual search for neighboring aircraft. It also helps the pilot maintain visual contact with other traffic as his attention and visual focus is divided among several cockpit duties. The essence of this application, then, is to assist the pilot in his external scan to visually acquire other traffic, and maintain visual contact once acquired.

1.3.1.2 Enhanced Traffic Situational Awareness

As higher proportions of the aircraft in a given airspace domain are equipped with ADS-B, the CDTI provides the flight crew with an increasingly comprehensive picture of the traffic situation in all weather environments, and regardless of whether visual acquisition is possible, or not. To the extent that it is provided in current-generation ACAS-based CDTIs, this increased traffic situational awareness has proved valuable in many different airspace environments. Having a better understanding of the traffic situation in the terminal environment, for example, enables the flight crew to be better prepared to understand and respond to ATC instructions.

1.3.1.3 Station Keeping and Maintenance of Established Separation

In these applications, the CDTI is used to maintain separation from other aircraft once that separation has been established by ATC. Examples include maintaining longitudinal separation from an aircraft ahead on the same track as might be implemented on a final approach course, or as part of an in-trail climb/descend procedure in an en route/oceanic airspace environment. Because the CDTI is now being used in some sense to manage the flight profile with respect another aircraft, it may be necessary to provide the pilot with additional information beyond that to simply support an enhanced situational awareness. Though operational procedures still need to be developed, such additional information might include, for example, a range indication and closure rate to the referenced aircraft.

Requirements in this document are intended to support these applications for appropriate classes of users.

1.3.1.4 Electronic Flight Rules (EFR)

A further extension on the use of the CDTI is the notion of Electronic Flight Rules (EFR). Under this concept, in certain airspace and by mutual pilot/controller agreement, responsibility for separation may be delegated to the pilot. The CDTI and other appropriate aids would then be used by the pilot to electronically "see and avoid" other aircraft, perhaps by applying the same right-of-way rules that are applied today under VFR operations.

1.3.2 Airborne Collision Avoidance and Conflict Management

As more operational experience is gained, it is likely that ADS-B will be tasked with various degrees of support for airborne collision avoidance and conflict management. This includes detection and resolution of potential collision/conflict situations in both the tactical and strategic sense. The *Minimum Aviation System Performance Standards for Airborne Separation Assurance* (RTCA/DO-XXX) describe several applications in which ADS-B plays a central role in collision avoidance and conflict resolution.

1.3.2.1 Airborne Collision Avoidance

ADS-B could be used to augment, or used in lieu of, current-generation airborne collision-avoidance technologies. This would include features to detect when another aircraft is posing a collision risk, as well as provision of advisories to the pilot to resolve such a hazard. These applications would be based primarily on SV data, and other relatively "near-term" intent information provided by ADS-B. Their implementation in the cockpit would likely be done in concert with other ADS-B applications, such as those mentioned above dealing with CDTI.

1.3.2.2 Airborne Conflict Management

Many aircraft avionics architectures include a means to capture the aircraft's longer-term intent in terms of the future lateral and vertical path, as well as the speed profile. This information can be shared in an ADS-B environment to detect potential conflicts long before more aggressive avoidance measures are necessary. In this future application, such a potential conflict could be displayed along with a range of possible resolution choices. In addition, any change in intent could be quickly evaluated against the intent of other equipped aircraft, thereby increasing the flexibility and capacity of the airspace. In this family of applications, greater strides toward Free Flight operations can be made.

1.3.3 Airport Surface Applications

There are a number of potential applications for ADS-B on and near the airport surface. These include the use of ADS-B to maintain traffic situational awareness for surface operations, much akin to its use in airborne environments. However, this situational awareness could also be extended to include equipped surface vehicles such as snow-removal equipment, crash/fire/rescue vehicles, or other vehicles that may be frequently operating in the airport movement area. Another set of applications promotes pilot awareness of takeoff and landing operations, and whether the active runway is occupied,

or in use by, another aircraft. These applications are aimed directly at reducing the incidence of runway incursions.

1.3.4 Support of Ground-Based Surveillance

UAT has been successfully demonstrated to provide "radar-like" services in environments where no SSR coverage exists, and future expansion of this application is quite promising. In this family of applications, ground-based monitoring stations are situated in areas where IFR departure and arrival procedures are conducted but no SSR coverage is available. By receiving, processing, and forwarding ADS-B messages to appropriate ATC facilities, the controller can be presented with traffic information that is very similar to what would be provided with traditional radar systems. Consequently, the controller can apply more efficient radar-based traffic separation techniques, thereby increasing traffic throughput and reducing delays. A variation of this application involves the use of ADS-B to provide a surface surveillance capability to ground controllers at towered airports, to aid in surface movement planning, monitoring, and runway occupancy.

1.3.5 Other Applications

RTCA/DO-242A outlines several other secondary applications, such as use of ADS-B to enhance flight following, search-and-rescue, and others that may be beneficial in terms of safety, efficiency, increased utility, or cost savings.

1.4 Test Procedures

The test procedures specified in this document are intended as one means of demonstrating compliance with the specified performance requirements. Although specific test procedures are cited, it is recognized that there are other suitable methods, and that these other procedures may be used if they provided at least equivalent confidence that the requirements are satisfied. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

The specified order of tests suggests that the equipment be subjected to a succession of tests as it moves from design, and design qualification, into operational use. For example, compliance with the requirements of Section 2 shall have been demonstrated as a precondition to satisfactory completion of the installed system tests of Section 3.

a. Environmental Tests

Environmental test requirements are specified in Section 3. The procedures and their associated limits are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

Unless otherwise specified, the environmental conditions and test procedures contained in RTCA Document No. DO-160C, *Environmental Conditions and Test Procedures for Airborne Equipment*, will be used to demonstrate equipment compliance.

b. Bench Tests

Bench test procedures are specified in Section 2. These tests provide a laboratory means of demonstrating compliance with the requirements of Section 2. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

c. Installed Equipment Tests

The installed equipment test procedures and their associated limits are specified in Section 3. Although bench and environmental test procedures are not included in the installed equipment test, their successful completion is a precondition to completion of the installed test. In certain instances, however, installed equipment test may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

1. With the aircraft on the ground and using simulated or operational system inputs.
2. With the aircraft in flight using operational system inputs appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

d. Operational Tests

The operational tests are specified in Section 4. These test procedures and their associated limits are intended to be conducted by operating personnel as one means of ensuring that the equipment is functioning properly and can be reliably used for its intended function(s).